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وزارة التعليم العالي والبحث العلمي
المدرسة الوطنية العليا في الأمن السيبراني

ALGORITHMS AND STATIC DATA STRUCTURES

CHAPTER 2: ALGORITHMIC FORMALISM (07h-08h)

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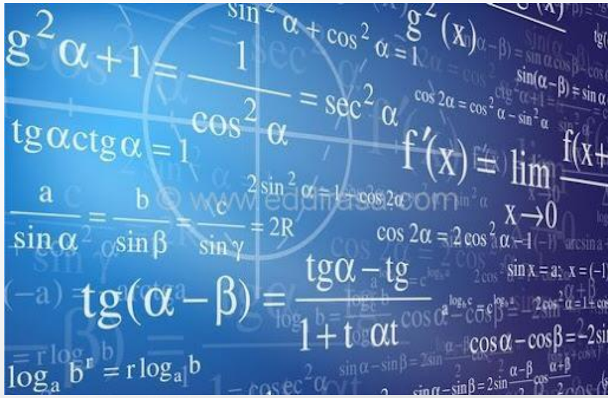
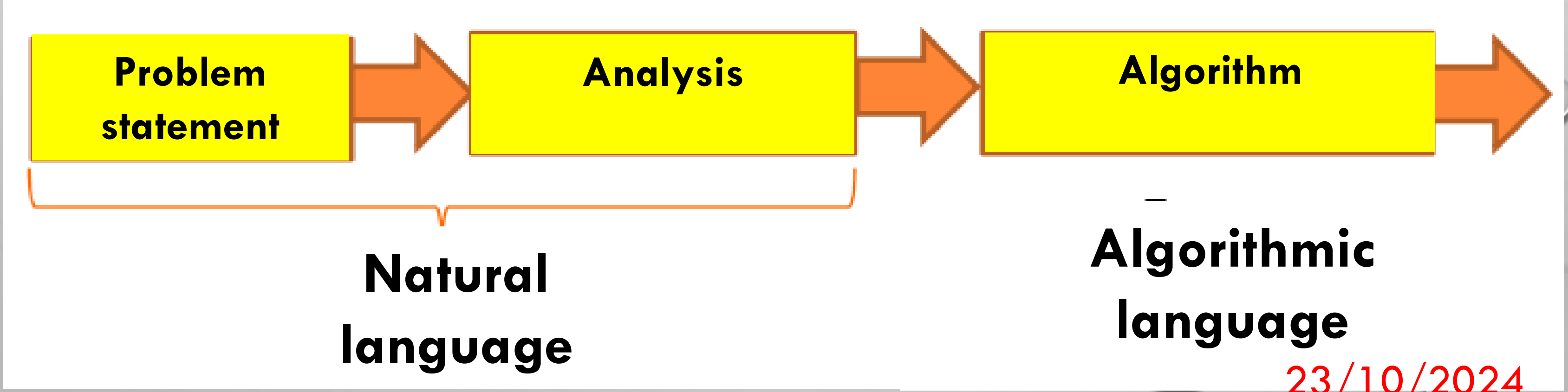
Algorithmic Formalism (1)

Why should we formalize?

- Once a problem has been analyzed, the designer must express the solution using a *universal formalism*, typically in the form of an *algorithm*.
- The challenge is to adopt a *common language*, allowing for the understanding of algorithms developed by others and vice-versa.



This highlights the importance of *formalism*



Algorithmic Formalism (2)

Definition (1)

- It is the precise representation of algorithms using formal language or notation, ensuring:
  - Clarity,
  - Unambiguity,
  - Systematic analysis for effective communication and verification.

Definition (2)

- An algorithmic formalism is a set of conventions (or rules) in which, is expressed, any solution to a problem.
- It is a common and precise language that allows communication without ambiguity.
  - It must be readable and understandable by multiple people.

Structure of an Algorithm (1)

An algorithm is organized (structured) into three parts

Header	**Algorithm** Name_of_the_Algorithm;
Declaration	**Environment** (Declaration of constants, variables, types, objects and modules used in the algorithm)

Body of the algorithm	**Begin**
	Action_1;
	Action_2;
	…
	Action_n;
	End;

Keywords:

- Algorithm
- Begin
- End

Structure of an Algorithm (2)

Header | **Algorithm** Name_of_the_Algorithm;

Header

- It simply serves to identify the algorithm.
- Indicates the name of the algorithm and possibly a brief description of its purpose.
- Generally, a descriptive name should be given to allow the reader to understand what the algorithm will do.

Algorithm Name_of_the_Algorithm; // role of the algorithm (optional)

Examples of Headers

- **Algorithm** Addition;
- **Algorithm** GCD;
- **Algorithm** Divisors;
- **Algorithm** Calculate_Circle_Area;
- **Algorithm** Sum_Integers;

Structure of an Algorithm (3)

Declaration

- **Constants**
- **Types**
- **Variables**
- **Sub-programs (functions, procedures)**

Declaration:

- Declares the necessary variables:
  - The identifiers within their data types
  - The input parameters.
- Declarations of input data, meaning the elements that are essential for its proper functioning.
- Declarations of output data, meaning the elements calculated or produced by the algorithm.
- Declarations of local data that are essential to the algorithm.

Structure of an Algorithm (4)

Environment (declaration part)

- It contains a comprehensive list of the objects used and manipulated within the body of the algorithm.
- It is placed at the beginning of the algorithm.
- Every algorithm uses objects that are declared in its environment.
- For each object, it is necessary to correspond:
  - A NAME (Identifier) that allows it to be designated and distinguished from the other elements.
  - A TYPE that indicates the nature of the set in which the object takes its values.
  - A VALUE assigned to this object at a given moment.

Variables **Identifier: Type;**

Structure of an Algorithm (5)

Identifier

- The construction of a name to uniquely designate an object follows precise rules in algorithmics and programming.
- The chosen name is called an **Identifier.**

Rules to follow:

- An IDENTIFIER must begin with an uppercase/lowercase LETTER and can consist of letters, digits, and/or the symbol "_" (underscore).
- An IDENTIFIER must not contain spaces (whitespace characters), accented characters, or characters such as "%", "?", "*", ".", "-" , …

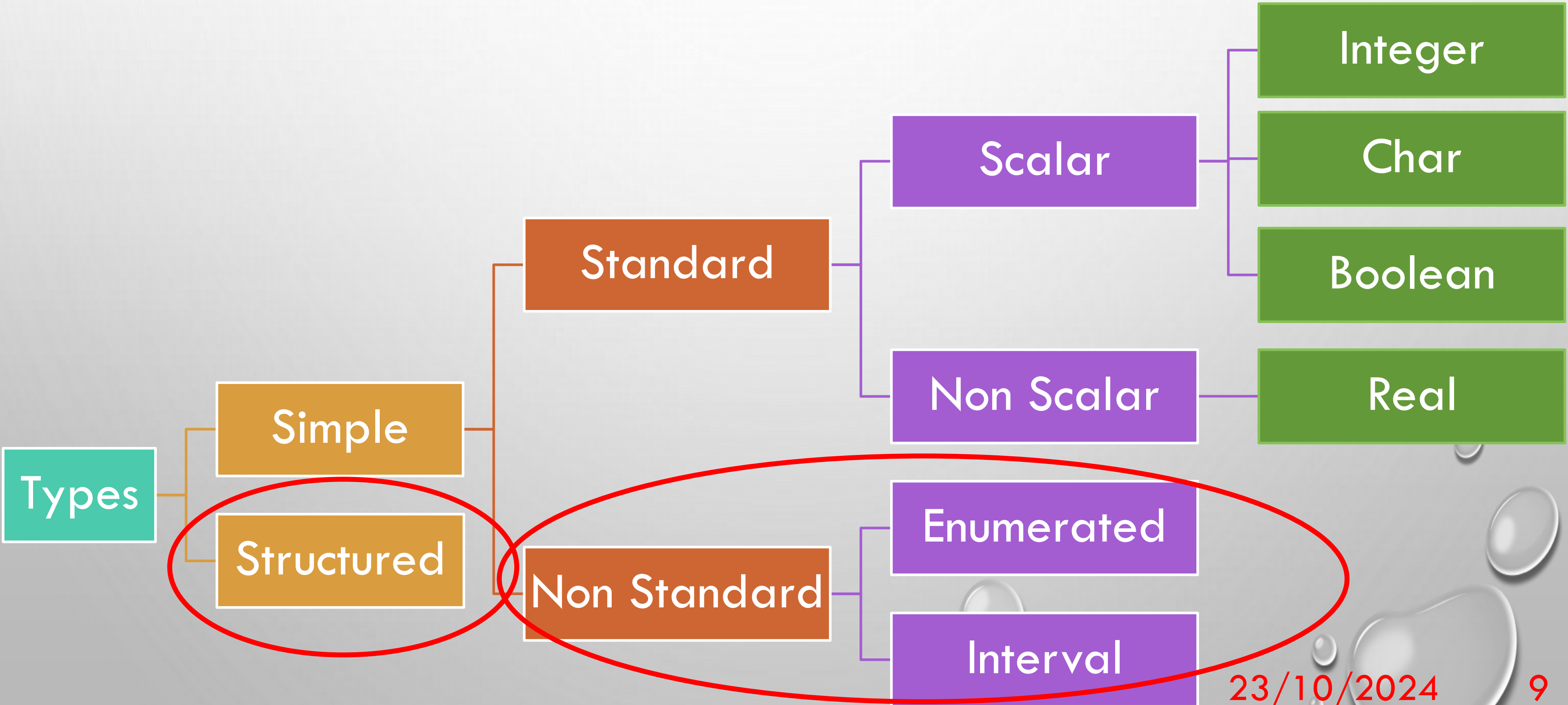
Examples of incorrect identifiers

- 34x (it does not start with a letter).
- velocity object (it contains a space between velocity and object).
- engine450.7hp! (it contains a "." and a "!").

Structure of an Algorithm (6)

TYPE

- It represents:
  - The set of values that an object belonging to it may take.
  - The authorized operations on that object.



Structure of an Algorithm (7)

Integer

- This is the set of integers
- In mathematics, this set is infinite
- On a computer, the values are limited by the length of the machine words.

Type	Interval	Length
shortint	-128...127	01 byte (08bits)
integer	-32 768...32 767	02 bytes
longint	-2 147 483 648...2 147 483 647	04 bytes
byte	0...255	01 byte
word	0...65 536	02 bytes

Structure of an Algorithm (8)

Char (Character)

- It corresponds to a single character.
- It includes all alphanumeric characters (alphabetic, numeric, special characters and space).
- The character set can vary.

- The values are ordered according to the internal character code:
  - ASCII (American Standard Code for Information Interchange)

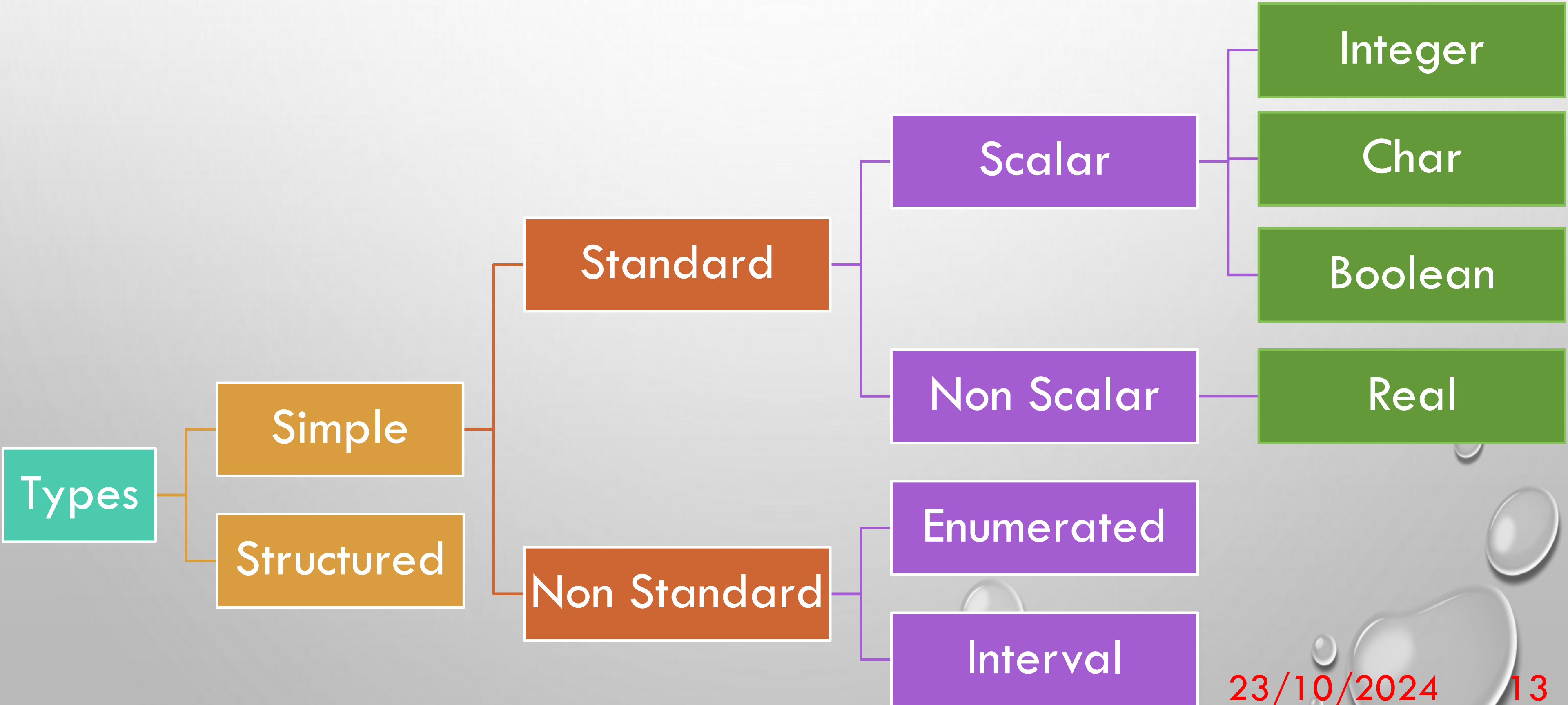
Structure of an Algorithm (9)

Code	Char	Code	Char	Code	Char	Code	Char	Code	Char	Code	Char
32		48	0	64	@	80	P	96	`	112	p
33	!	49	1	65	A	81	Q	97	a	113	q
34	"	50	2	66	B	82	R	98	b	114	r
35	#	51	3	67	C	83	S	99	c	115	s
36	$	52	4	68	D	84	T	100	d	116	t
37	%	53	5	69	E	85	U	101	e	117	u
38	&	54	6	70	F	86	V	102	f	118	v
39	‘	55	7	71	G	87	W	103	g	119	w
40	(	56	8	72	H	88	X	104	h	120	x
41	)	57	9	73	I	89	Y	105	i	121	y
42	*	58	:	74	J	90	Z	106	j	122	z
43	+	59	;	75	K	91	[	107	k	123	{
44	,	60	<	76	L	92	\	108	l	124	|
45	-	61	=	77	M	93	]	109	m	125	}
46	.	62	>	78	N	94	^	110	n	126	~
47	/	63	?	79	O	95	_	111	o	127	

Structure of an Algorithm (10)

Boolean (Logical)

- This is the set of two values:
  - True
  - False



Structure of an Algorithm (11)

Real

- This is the set of numbers having a fractional part.
- This set is also limited
- The limits are wider and depend on the internal representation (Architecture of computers).

±integer part.decimal part

Type	Interval	Length	Number of digits
Real	$2.9*10^{-39}...1.7*10^{38}$	06 bytes	11-12
Single	$1.5*10^{-45}...3.4*10^{38}$	04 bytes	07-08
Double	$5.8*10^{-324}...1.7*10^{308}$	08 bytes	15-16

Structure of an Algorithm (12)

Constant

- Some identifiers have a constant value (that does not change) during the **entire** execution of the algorithm.
- This data is not variable but constant.
- These identifiers are called constants.
- They are declared at the beginning of the algorithm by following the identifier with its value.

Constant Constant_Identifier=Value;

How does it work ?

- Some information manipulated by a program never changes.
- Instead of explicitly placing their value in the text of the program, it is preferable to give them a symbolic (and meaningful) name.
- This is the case for the value of:
  - π (Constant of Archimedes): **PI=3.14159265359**
  - Gravity on earth: **G=9.80665m/s²**
  - etc.

Structure of an Algorithm (13)

Body

- The body of the algorithm contains a sequence of:
  - Actions (instructions).
  - Executed in the order they appear in the algorithm.
- It starts by **Begin**
- It ends by **End;**

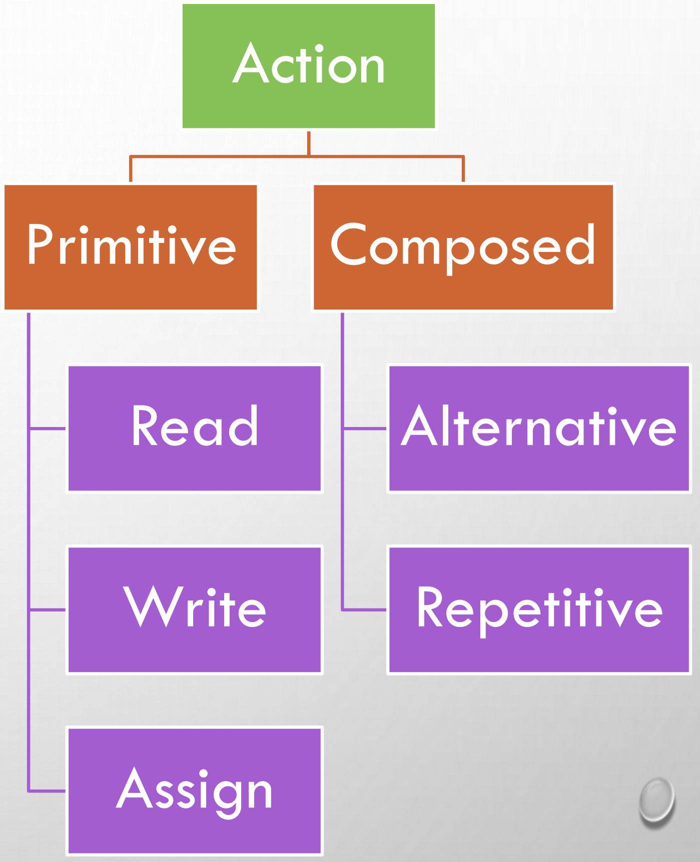
Body of the algorithm

Begin
Action_1;
Action_2;
…
Action_n;
End;

Begin
read(a);
read(b);
average=(a+b)/2;
print(average);

Action

- An event that acts on the variables by modifying their values or by observing them.
- Two types of actions:
  - o **Elementary (primitive)**:
    - ▪ Executed without any additional information.
  - o **Composed**: Composed of several other primitive actions.
    - ▪ Executed under certain conditions (once or repeated).
    - ▪ Control structures.



Primitive actions (1)

Reading

- Reading a value from an input device (usually the keyboard) and then storing the read value in a variable.
- In case of several variables to read, simply separate them with ",".

read(variable);

read(variable_1, variable_2 … variable_n);

- Reading blocks the execution until the values are received and stored in the variables.
- The values read from the keyboard are assigned to the variables respectively, while verifying type compatibility.

```
a, b: integer;
delta: real;
read(a);
read(b);
read(delta);
```

Primitive actions (2)

Writing/Displaying

- Write/Display the values of the objects mentioned in the list.
- In case of several variables to write/display, simply separate them with ",".

print(variable);
print(variable_1, variable_2 … variable_n);
print("The value of Expression = ", expression);

An object can be:

- A value, such as "5", "Hello" …
  - A value is displayed as it is.
- A variable, such as x, y …
  - A variable is replaced by its value.
- An **expression**, such as (x+y)/2, (a **or** b),√delta …
  - First, **expression** is evaluated.
  - Second, result is displayed.

Primitive actions (3)

Example: Give the results of each action

- a=5; print (a);
- c=4; print ("c=", c) ;
- b=a*a-c; print (a*a-c);
- print(a, b, c);
- print(a,   b,   c);
- print(a, " ", b, " ", c);
- print("a=", a, " b=", b, " c=", c);

- 5
- c=4
- 21
- 5214
- 5214
- 5 21 4
- a=5 b=21 c=4

Primitive actions (4)

Assignment

- Evaluate the entity located on the right of the assignment (expression).
- Put the result in the entity located on the left.

- Expression type must be compatible with the type of the left variable.
- The previous value of the left variable is lost (overwritten).

Instruction	y	x	x1	y1
y=2;	2	?	?	?
x=y;	2	2	?	?
x=x+2;	2	4	?	?
x1=y+x;	2	4	6	?
y1=x1+2;	2	4	6	8
y1=y1*2;	2	4	6	16
x=y1+3;	2	19	6	16

Primitive actions (5)

```
Algorithm Second_Degree_Solution;
Variables
    a, b, c, delta: integer;
    x1, x2: real;
Begin
    read(a);
    read(b);
    read(c);                    // ax²+bx+c=0
    delta=b*b-4*a*c;            // delta≥0
    x1=(-b-√delta)/(2*a);          // √delta returns the square root of delta
    x2=(-b+√delta)/(2*a);
    print(delta);
    print(x1);
    print(x2);
End;
```

Conditional (1)

IF statement

```
IF (Condition)
Begin
    Action_1;
    …                //BLOCK
    Action_n;
End;
Action_(n+1);
```

- If **Condition** is TRUE, the BLOCK (*Action_1 … Action_n*) is executed.
- Otherwise, it goes to *Action(n+1)*.

- **Condition** is a Boolean expression:
  - An expression that evaluates to either **TRUE** or **FALSE**.

Important

- A block is a coherent set composed of one or several actions.
- A block begins with **Begin** and ends by **End;**
- In case a block is composed of one primitive action only, **Begin** and **End** are facultative.

IF statement

```
Algorithm Second_Degree_Solution;
Variables
    a, b, c: integer;     delta, x1, x2: real;
Begin
    read(a);    read(b);    read(c);     // ax²+bx+c=0
    delta=b*b-4*a*c;
    IF(delta>=0)
    Begin
        x1=(-b-√delta)/(2*a);
        x2=(-b+√delta)/(2*a);
        print(x1);
        print(x2);
    End;
End;
```

Alternative (1)

IF-ELSE statement

```
IF (Condition)
Begin
     Action_1;
     …                //BLOCK 1
     Action_3;
End;
Else
Begin
     Action_4;
     …                //BLOCK 2
     Action_8;
End;
Action_9;
```

- If **Condition** is TRUE, the BLOCK1 (*Action_1* … *Action_3*) is executed.
- Otherwise, the BLOCK 2 (*Action_4* … *Action_8*) is executed.

Alternative (2)

IF-ELSE statement

```
Algorithm Sign_Integer;
Variables
    number: integer;
Begin
    read(number);
    IF(number<0) print("Negative number");
    Else          // number≥0
    Begin
        IF(number>0) print("Positive number");
        Else    print("Zero");        // number=0
    End;
End;
```

Alternative (3)

IF-ELSE statement

```
Algorithm Second_Degree_Solution; // Find solutions in ℜ
Variables  a, b, c, delta: integer;  x1, x2: real;
Begin
    read(a);    read(b);    read(c);     // ax²+bx+c=0
    delta=b*b-4*a*c;
    IF(delta<0) print("No solutions");
    Else          // delta≥0
    Begin
        If(delta>0)
        Begin
            x1=(-b-√delta)/(2*a);          // SQRT(delta), Square Root
            x2=(-b+√delta)/(2*a);
        End;
        Else    x1=x2=-b/(2*a);
        print(x1);       print(x2);
```

Alternative (4)

SWITCH-CASE statement

```
Algorithm Switch_Case;
Variables   a: integer;
Begin
    read(a);
    IF (a=1)
    Begin
        Block 1;
    End;
    Else
        IF (a=2)
        Begin
            Block 2;
        End;
        Else
        Begin
            IF (a=3)
            Begin
                Block 3;
            End;
            Else
                IF (a=4)
                Begin
                    Block 4;
                End;
                Else
                Begin
                    Block 5;
                End;
            End;
        End;
    End;
End;
```

Alternative (5)

SWITCH-CASE statement

```
switch (expression)
Begin
    case value1:
        Action_1;
        ...
        Action_6;   break;
    case value2:
        Action_7;
        ...
        Action_10; break;
    ....
    default:
        Action_n;
        break;
End;
```

- **switch case** statement is an alternative to the **IF-ELSE** statement.
  - It is used to execute the conditional code based on the value of the **expression** specified in the switch statement.
- The **default** block is optional.
  - It defines the actions to be executed if the value of **expression** does not correspond to any case.

Note

- expression should evaluate to either integer or character.
- It cannot evaluate any other data type.

Alternative (6)

SWITCH-CASE statement

```
Algorithm Switch_Case;
Variables
    a: integer;
Begin
    read(a);
    switch (a)
    Begin
        case 1:
            Block 1;
            break;
        case 2:
            Block 2;
            break;
        case 3:
            Block 3;
            break;
        case 4:
            Block 4;
            break;
        default:
            Block 5;
            break;
    End;
End;
```

Alternative (7)

SWITCH-CASE statement

```
Algorithm switch_case_statement;
Variables cas: integer;
Begin
    read(cas);
    switch (cas)
    Begin
        case 1:
            printf("Case 1 is executed");   break;
        case 2:
            printf("Case 2 is executed");   break;
        default:
            printf("Default Case is executed");     break;
    End;
End;
```

Alternative (8)

Example: Write an algorithm that reads the number of a month and displays the number of days.

```
Algorithm number_days_months_If-Else;
Variables month : Integer;
Begin
    print("Give the number of the month [1…12]:");
    read(month);
    IF ((month=1) or (month=3) or (month=5) or (month=7) or (month=8)
    or (month=10) or (month=12))      print("This month is 31 days");
    Else
        IF ((month=4) or (month=6) or (month=9) or (month=11))
            print("This month is 30 days");
        Else
            IF (month=2) print("This month is 28 or 29 days");
            Else print ("ERROR: Invalid month");
End;
```

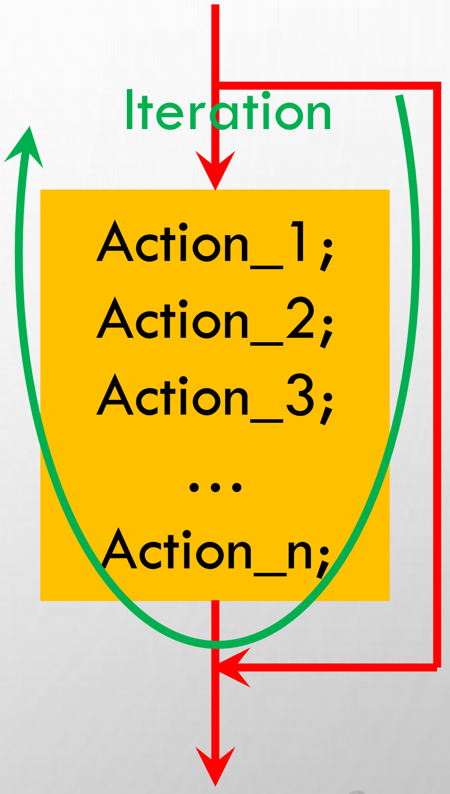
Alternative (8)

Example: Write an algorithm that reads a month number and displays the number of days.

```
Algorithm number_days_months_Switch_Case;
Variables month : Integer;
Begin
    print("Give a number of a month [1…12]:");  read(month);
    switch (month)
    Begin
        case 1, 3, 5, 7, 8, 10, 12: print("This month is 31 days");
                                    break;
        case 4, 6, 9, 11:           print("This month is 30 days");
                                    break;
        case 2:                     print(" This month is 28 or 29 days");
                                    break;
        default:                    print ("ERROR: invalid month"); break;
    End;
End;
```

Loops

- Many processes require repeating a block several times, with possible variation of parameters.
- A Loop allows executing an instructions block several times according to a condition.
- Each execution of the block is called an **iteration.**
- There are three forms of repetitive (loops):
  - **For.**
  - **While.**
  - **Do … While.**
- When the number of iterations is a priori known, often use **For** loop.
- Otherwise (unknown), use the other loops (**While, Do … While**).
  - If the loop is executed at least once (≥1), use **Do … While** loop.
  - If the loop may not be executed (≥0), use **While** loop.



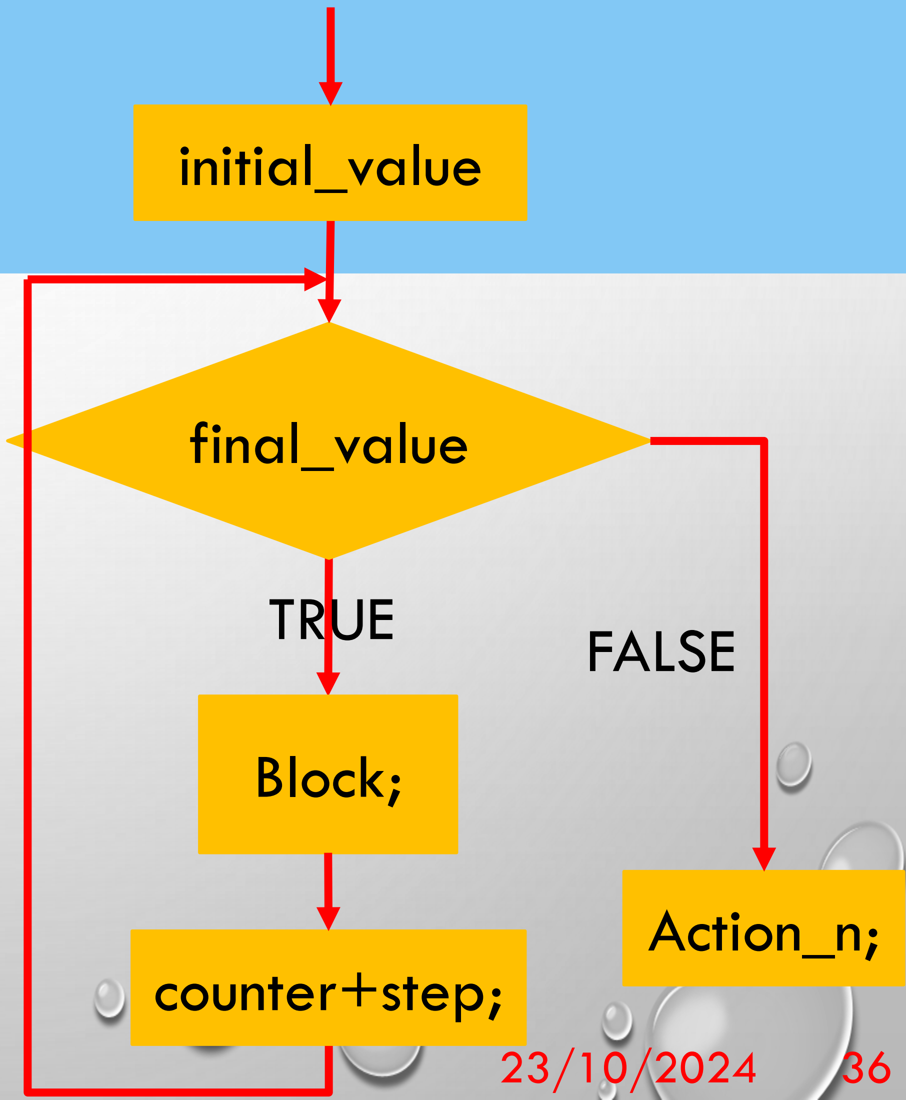
FOR loop (1)

For (*counter*=initial_value; *counter*≤final_value; *step*)
Begin
    Block;
End;
Action_n;

- *counter* is used to enumerate the iterations.
  - *counter* is called the loop counter.
- *initial_value*, *final_value* and *step*: can be integer constants, integer variables, or integer expressions.
- **For** loop is used if:
  - repetitions number is known.
  - *initial_value* and *final_value* of *counter* are known.
- *counter* will take the values [*initial_value* … *final_value*] by adding *step* value each time.
- For each value of *counter*, the block is executed.

FOR loop (2)

For (*counter*=initial_value; *counter*≤final_value; *step*)
Begin
    Block;
End;
Action_n;



Warning!

- Do not modify the *counter* and the *final_value* inside the loop:
  - disrupts the number of iterations planned by **For** loop.
  - presents the risk of an infinite loop.

FOR loop (3)

For (*counter*=initial_value; *counter*≤final_value; *step*)
Begin
    Block;
End;
Action_n;

How does it work?

1. Initialize *counter*=initial_value;
2. Evaluate the stop ***Condition***: (counter>final_value)?
3. In case (***Condition* = TRUE**)
   - Execute Block;
   - counter=counter+step;
   - Goto 2;
4. Otherwise (**Condition = FALSE**)
   - Execute Action_n;

FOR loop (4)

Example 1: Write three algorithms to display the integer numbers multiple of 10 in the interval [0, 50]

```
For (i=0; i≤50; i=i+10)
Begin
    print(i);
End;
```

```
0
10
20
30
40
50
```

FOR loop (5)

Example 2: Write three algorithms to display the integer numbers multiple of 5 in the interval [30, 5]

```
For (i=30; i≥5; i=i-5)
Begin
    print(i);
End;
```

```
30
25
20
15
10
5
```

FOR loop (6)

Example 3: Write an algorithm to display the sum of integer numbers [1, 100]

```
Algorithm sum_100_integers;
Variables
    i, sum: integer;
Begin
    sum=0;
    For (i=1; i≤100; i=i+1)
    Begin
        sum=sum+i;
    End;
    print("Sum of the first 100 numbers=", sum);
End;
```

FOR loop (7)

Example 4: Write an algorithm to display the integer numbers [1, 100] multiple of 5.

```
Algorithm multiple_5_less100_1st;
Variables
    i: integer;
Begin
    For (i=5; i≤100; i=i+5)
    Begin
        print(i);
    End;
End;
```

```
Algorithm multiple_5_less100_2nd;
Variables
    i: integer;
Begin
    For (i=1; i≤20; i=i+1)
    Begin
        print(5*i);
    End;
End;
```

FOR loop (8)

Example 5: Write an algorithm to display all the divisors of an integer number *n*.

```
Algorithm divisors_of_n;
Variables n, i: integer;
Begin
    print("Give a positive integer number, n=");
    read(n);
    print("The divisors are: 1, ");
    For (i=2; i≤n/2; i=i+1)
    Begin
        If(n%i==0) print(i, ", ");
    End;
    print(n);
End;
```

FOR loop (9)

Nested FOR loops

```
For (counter_1=initial_value_1; counter_1≤final_value_1; step_1)
Begin
    Action_1 … Action_m;
    For (counter_2=initial_value_2; counter2≤final_value_2; step_2)
    Begin
        Block_of_Inner_Loop;
    End;
    Block_of_Outer_Loop;
End;
```

- A nested loop has one loop inside of another.
- When a loop is nested inside another loop, the inner loop runs many times inside the outer loop.
- Each iteration of the outer loop, the inner loop will be re-started.
- The inner loop must finish all of its iterations before the outer loop can continue to its next iteration.

FOR loop (10)

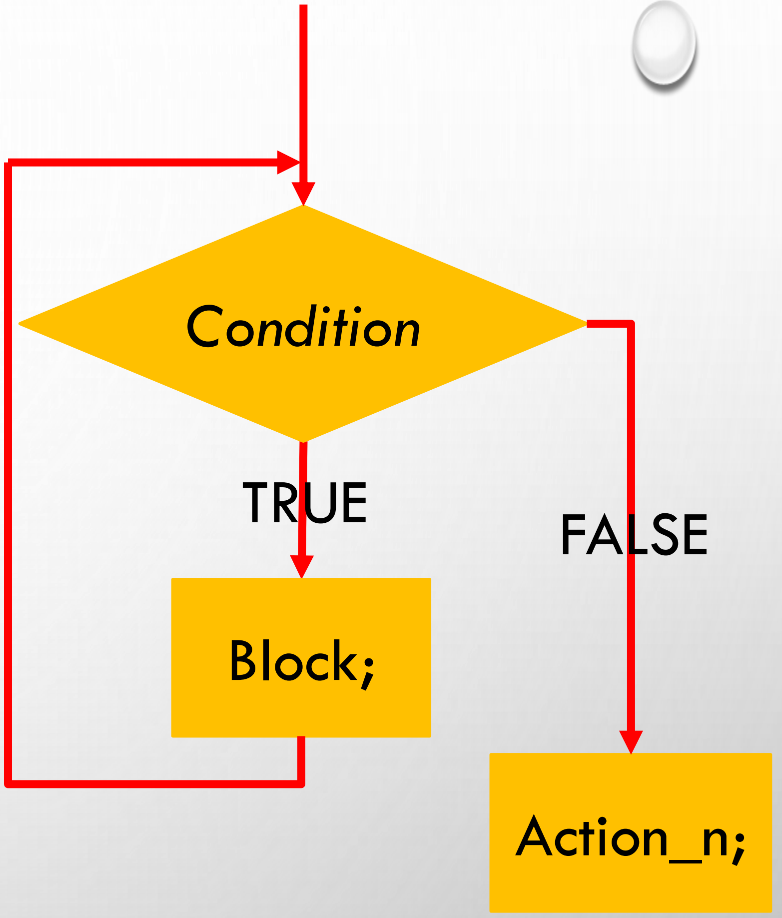
Example 6: Write an algorithm to display the elements (rows and columns) of a matrix [3,2] of two dimensions.

```
Algorithm Rows_Columns_2D_Matrix;
Variables row, column: integer;
Begin
    For (row=1; row≤3; row=row+1)
    Begin
        For (column=1; column≤2; column=column+1)
         Begin
            print("Element[", row, ",", column]"=", matrix[row, column]);
        End;
    End;
End;
```

```
Element[1,1]=xy
Element[1,2]=xz
Element[2,1]=yx
Element[2,2]=yz
Element[3,1]=zx
Element[3,2]=zy
```

WHILE loop (1)

While (*Condition*)
Begin
    Block;
End;
Action_n;



The form of the **While(Condition)** loop is as follows:

- ***Condition*** must be computable (before each iteration).
- **Block** of the loop may never be executed.
- **Block** must modify the condition variables (to avoid infinite loop).

WHILE loop (2)

```
While (Condition)
Begin
    Block;
End;
Action_n;
```

How does it work?

1. Evaluate the **Condition**?
2. In case (**Condition = TRUE**)
   - Execute Block;
   - **Goto** 1;
3. Otherwise (**Condition = FALSE**)
   - Execute Action_n;

WHILE loop (3)

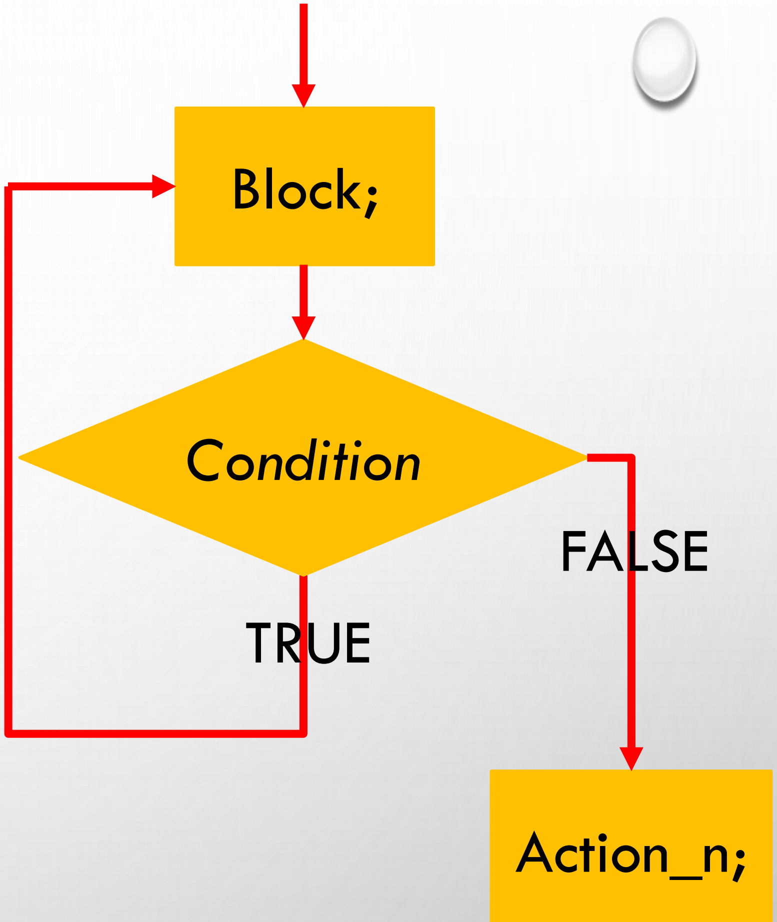
Example 1: Write an algorithm to calculate the set of divisors of a number *n*.

```
Algorithm Number_Divisons;
Variables n, i: integer;
Begin
    print("Enter a number, n=");    // read a number n
    read(n);
    i=1;
    While(i≤n)        // run i = 1, 2 … n
    Begin
        If (n%i==0)            // i is a divisor of n
            print(i);
        i=i+1;                 // Make sure we move to the next number
    End;
End;
```

Do … WHILE loop (1)

Do
Begin
    Block;
End;
While(*Condition*);
Action_n;

Do
    Block;
While(*Condition*);
Action_n;



- Both forms are equivalent:
    - **Begin-End;** are optional.
- *Condition* is calculated after each iteration.
- *Block* of the loop is executed at least once.
- *Block* must modify the variables of the condition (to avoid infinite loop).

Do … WHILE loop (2)

```
Do
Begin
    Block;
End;
While(Condition);
Action_n;
```

```
Do
    Block;
While(Condition);
Action_n;
```

How does it work?

1. Execute Block;
2. Evaluate the **Condition**?
3. In case (**Condition = TRUE**)
   - **Goto** 1;
4. Otherwise (**Condition = FALSE**)
   - Execute Action_n;

Loops (1)

Example 1: Translate the following **"For"** loop into **"While"** loop.

```
For (i=0; i≤50; i=i+10)
Begin
    print(i);
End;
```

```
i=0;
While(i≤50)
Begin
    print(i);
    i=i+10;
End;
```

Loops (2)

Example 2: Translate the following **"For"** loop into **"While"** loop.

```
For (j=30; j≤5; j=j-5)
Begin
    print(j);
End;
```

```
j=30;
While(i≥5)
Begin
    print(j);
    j=j-5;
End;
```

Loops (3)

Example 3: Translate the following **"For"** loop into **"While"** loop.

```
For (i=1; i≤3; i=i+1)
Begin
    For (j=1; j≤2; j=j+1)
    Begin
        print("i=", i, " j=", j);
    End;
End;
```

```
i=1;
While (i≤3)
Begin
    j=1;
    While (j≤2)
    Begin
        print("i=", i, " j=", j);
        j=j+1;
    End;
    i=i+1;
End;
```

Loops (4)

Example 4: Translate the following **"For"** loop into **"Do…While"** loop.

```
For (i=0; i≤50; i=i+10)
Begin
    print(i);
End;
```

```
i=0;
Do
Begin
    print(i);
    i=i+10;
End;
While(i≤50)
```

```
i=0;
Do
    print(i);
    i=i+10;
While(i≤50)
```

Loops (5)

Example 5: Translate the following **"For"** loop into **"Do…While"** loop.

```
For (j=30; j≤5; j=j-5)
Begin
    print(j);
End;
```

```
j=30;
Do
Begin
    print(j);
    j=j-5;
End;
While(j≥5)
```

```
j=30;
Do
    print(j);
    j=j-5;
While(j≥5)
```

Loops (6)

Example 6: Translate the following **"For"** loop into **"Do…While"** loop.

```
For (i=1; i≤3; i=i+1)
Begin
    For (j=1; j≤2; j=j+1)
    Begin
        print("i=", i, " j=", j);
    End;
End;
```

```
i=1;
Do
    j=1;
    Do
        print("i=", i, " j=", j);
        j=j+1;
    While (j≤2);
    i=i+1;
While (i≤3);
```

```
i=1;
Do
Begin
    j=1;
    Do
    Begin
        print("i=", i, " j=", j);
        j=j+1;
    End;
    While (j≤2);
    i=i+1;
End;
While (i≤3);
```

Loops (7)

Remarks

- **While** and **Do … While** forms are used when the number of loops (iterations) is unknown:
  - For **Do … While** form, it is at least equal to 1.
  - For **While** form, it can be equal to 0.

- This difference often allows to choose between both forms.

Warning!

Beware of design errors that can lead to an "infinite loop", when **Condition** always remains verified.

Loops (8)

Exercise 1: Write an algorithm that reads a positive integer *n*, then double it as needed until it exceeds 60.

```
Algorithm Double_Less_60;
Variables n : Integer;
Begin
    Do
        print("Give a positive integer n=");
        read(n);
    While(n≤0);
    While (n≤60)
    Begin
        n=n*2;
    End;
    print("n=" , n);
End;
```

Exercise 2: Write an algorithm that calculates the sum of *n* integers (*n*>0) as well as their average.

```
Algorithm Sum_Average;
Variables number_integers, x, sum : Integer; moy: real;
Begin
    Do
        print("Give a positive integer n=");    read(number_integers);
    While(n≤0);
    For (i=1; i≤number_integers; i=i+1)
    Begin
        print("Give an integer x=");    read(x);
        sum=sum+x;
    End;
    moy=sum/number_integers;
    print("Sum=", sum);     print("Average=", moy);
End;
```

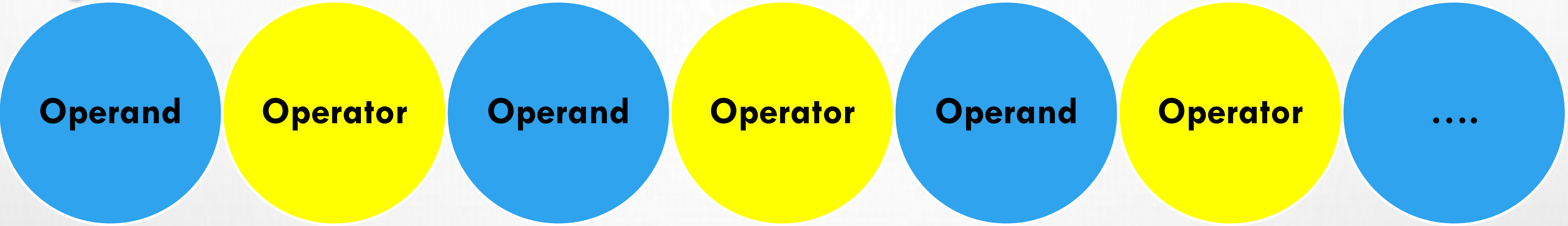
Loops (10)

Exercise 3: Write an algorithm that displays the minimum of *n* read integer numbers (*n*>0)

```
Algorithm min_N_Integers;
Variables n, i, min: Integer;
Begin
    Do
        print("Give a positive integer n=");    read(n);
    While (n≤0);
    print("Give an integer=");      read(min);
    For (i=2; i≤n; i=i+1)
    Begin
        print("Give and integer x=");      read(x);
        If(x<min) min=x;
    End;
    print ("Minimum=", min);
End;
```

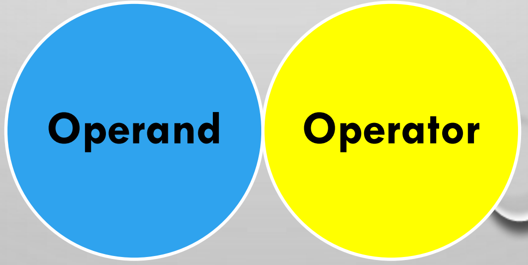
Expressions

Expressions



Binary operators

Unary operators



Arithmetic expressions (1)

- **Operand**: integers, reals
- **Operators:** + (plus), - (minus), / (slash), * (asterisk), % (modulo)

- **/ (slash): division:**
  - **result=operand_1/operand_2;**
  - In case **result** is integer, the division result will be an integer.
  - In case **result** is real, the division result will be an integer.

```
Variables  ope1, ope2, res_int: integer;
           res_real: real;
Begin
    read(ope1);    read(ope2);
    res_int=ope1/ope2;
    res_real=ope1/ope2;
    print("res_int=", res_int);
    print("res_real=", res_real);
End;
```

```
ope1=20;
ope2=3;
res_int=6;
res_real=6.33;
```

Arithmetic expressions (2)

- **Operand**: integers, reals
- **Operators:** + (plus), - (minus), / (slash), * (asterisk), % (modulo)

- **% (modulo): division remainder:**
  - **remainder=operand_1 % operand_2;**

```
Variables  ope1, ope2, rem: integer;
Begin
    read(ope1);
    read(ope2);
    rem=ope1 % ope2;
    print("remainder=", rem);
End;
```

ope1=20;
ope2=3;
remainder=2;

Arithmetic expressions (3)

Priority of operators:

*, /, %

+, -

- The hierarchy of operators defines how an expression is evaluated.
  - It starts with operators with highest hierarchy.
  - Then, moves to those with immediately lower hierarchy.
- In case of arithmetic expression:
  - It starts by carrying out all multiplications, divisions, and modulos.
  - Then, it moves to additions and subtractions.
- In case of same hierarchy, expression is evaluated from left to right.

v = a + b / d - x * z + x * y

Arithmetic expressions (4)

- Types must be respected; otherwise, errors may occur during execution.
- Type of arithmetic expression results depends on operators and operands types:

Operators	Operands type	Result type
+, -, *	integer … integer real … real real … integer integer … real	integer real real real
/ (real variable)	integer / integer real / real real / integer integer / real	real real real real
/ (integer variable)	integer / integer real / real real / integer integer / real	integer integer integer integer
%	integer % integer	integer

Logical expressions

- **Operand:** TRUE, FALSE
- **Operators:** && (and), | | (or), ! (not)

Priority of operators:

!

&&

| |

- **&&** and **| |** operators are binary because they require two operands.
- **!** operator is unary because it requires only one operand.

result = a | | c && b && ! d

Relational expressions

- **Operands:** Numerical, Alphanumerical
- **Operators:** =, >, >=, <, <=, !=

Priority of operators:

- Operators have the same priority.

a<b

a!=b

a>=b

Mixed expressions

- **Operands:** any
- **Operators:** any

Priority of operators:

!

*,   /,   %,   &&

+,   -, ||

=,   >,   >=,   <,   <=,   !=

(a * b > c) || (a / c = 0) && (x || ! y) && (b % c >= r)

Utilization of parentheses (1)

- Complex expressions require using parentheses, because they must be expressed in a linear form (on the same line).
- Expressions inside parentheses are evaluated first, starting with the innermost ones.

Example 1

$$Value = \frac{L * B * F}{\frac{F * B + n}{d} + e}$$

Value = (L* B* F) /((((F * B) + n) / d) + e)

Value = L * B * F /((F * B + n) / d + e)

Utilization of parentheses (2)

Example 2

$$frac = \frac{a+b}{c-d}$$

frac=(a+b)/(c-d)

Example 3

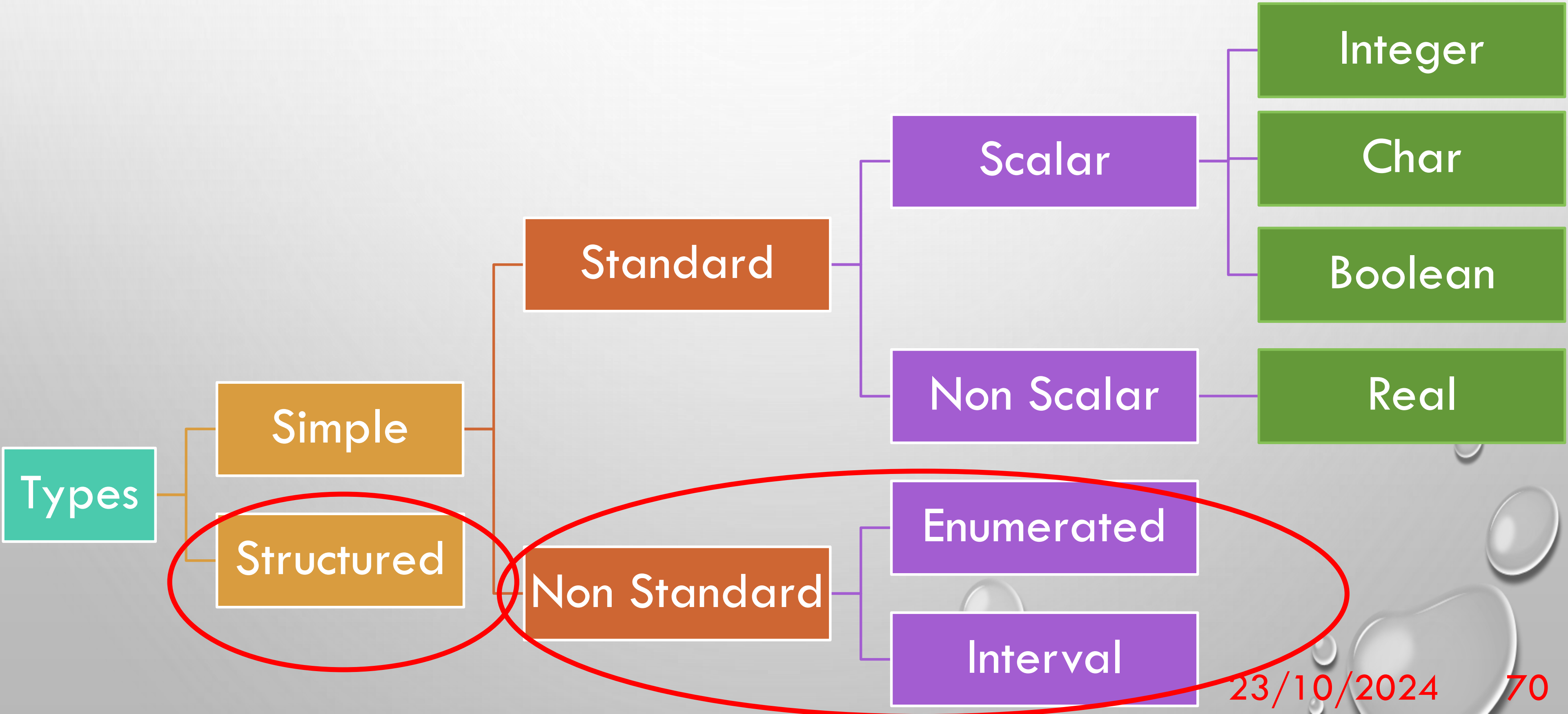
$$data = (\frac{percentage}{15} - \frac{var1 + var2}{20}) * (\mathrm{var3} + \mathrm{var4})$$

data= ((percentage/15) – ((var1+var2) / 20))*(var3+var4)

Non-standard types (1)

Specific types may be defined to the problem through non-standard types:

- Enumerated.
- Interval.



Non-standard types (2)

Enumerated type

- It defines an ordered set of values designated by identifiers (constants) (256 max).

Type *name_of_the_type={element_1, element_2 … element_n};*

Examples

Type

- Days={Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday};
- Colors={Red, Green, Blue, Yellow, Orange, White, Black};
- Size={Very big, Big, Average, Small, Very small};
- Answers={Yes, No, May_be};
- Feast={Aid_El_Fitr, Aid_El_Adha, Moharram, Achoura, Mouloud};
- Months={January, February, March, April, May, June, July, August, September, October, November, December};

Non-standard types (3)

Interval type

- It defines an interval of an ordered values set already defined from an ordinal type by indicating its lower and upper bounds.
- The type of both constants limiting the interval specifies the basic ordinal type of this interval.
- In Interval type, values are scalars and *Constant_1* must be greater than *Constant_2*.

Type *name_of_the_type=Constant_1 … Constant_2;*

Examples

Type

- Indices=1…10;
- Digit='0'…'9';
- Upper='A'… 'Z';
- Lower='a'… 'z';

Non-standard types (4)

Example: Let consider the following declarations:

```
Algorithm Non-Standard_Types;
Type
    Feast={Aid_El_Fitr, Aid_El_Adha, Moharram, Achoura, Mouloud};
    Months={January, February, March, April, May, June, July, August,
    September, October, November, December};
Variables f: Feast; m: Months;
```

```
Begin
     vacation=0;
     print("Give a month m="); read(m);
     If(m>=March) and (m<=June)
         print("It is Spring");
     For (f=Aid_El_Fitr; f<=Mouloud; f++)
         vacation=vacation+1;
End;
```

Non-standard types (5)

- It is possible to create a non-standard type from another one.

Example:

Type

Rainbow={Violet, Indigo, Blue, Green, Yellow, Red};

Year={September, October, November, December, January, February, March, April, May, June, July, August};

Color=Violet…Green;

Academic_Year= October…June;

Non-standard types (5)

```
Algorithm Final_Example_Chapter_Two;
Constant   PI = 3.14;  Hundred = 100;
Types
    Answer ={Yes, No};
    Feast={Aid_El_Fitr, Aid_El_Adha, Moharram, Achoura, Mouloud};
    Months={January, February, March, April, May, June, July, August,
    September, October, November, December};
    NumberMonths = 1…12;
    Temperature = -15 … 60;
    LowerCase = ‘a’ … ’f’;
Variables
    index, lowerIndex, higherIndex: Integer;   result, total: Real;
    num : NumberMonths;                vacation : Feast;
    resp : Answer;                     temp : Temperature;
    code1, code2 : LowerCase;          m1, m2, m3 : Months;
```

Thank You!

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